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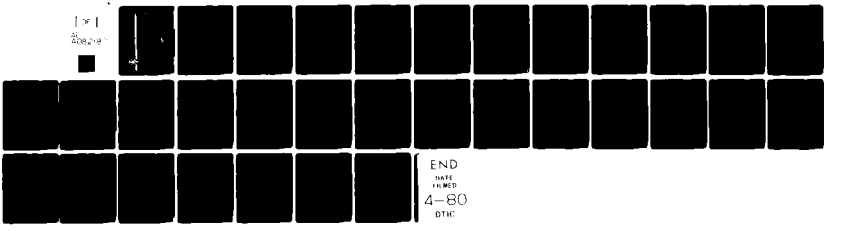

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Report 2287

COMMERCIAL AUTOMOTIVE ENGINE OILS – A LABORATORY ASSESSMENT OF THEIR QUALITY

by
John G. Sonnenburg
and
M. E. LePera

December 1979

U.S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT COMMAND
FORT BELVOIR, VIRGINIA

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 2287	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMMERCIAL AUTOMOTIVE ENGINE OILS – A LABORATORY ASSESSMENT OF THEIR QUALITY.		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John G. Sonnenburg and M. E. LePera		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Energy & Water Resources Laboratory, DRDME-GL; US Army Mobility Equipment Research and Development Command; Fort Belvoir, VA 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1L762733AH20
11. CONTROLLING OFFICE NAME AND ADDRESS Energy & Water Resources Laboratory, DRDME-GL; US Army Mobility Equipment Research and Development Command; Fort Belvoir, VA 22060		12. REPORT DATE December 1979 13. NUMBER OF PAGES 34
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Chemical/Physical Properties
Engine Sequence Tests
Spectrographic Analysis
Performance Level
Commercial Automotive Engine Oils
Additive Treatment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Commercial automotive engine oils were investigated in an attempt to determine their overall performance effectiveness. Physiochemical data were developed on the 17 samples to assist in this study. Standard inspection tests were employed as well as additional laboratory performance-type tests. The data developed indicated many of the oils do not comply with the physical/chemical requirements of MIL-L-46152. This failure could cause potential performance problems in automotive engines.

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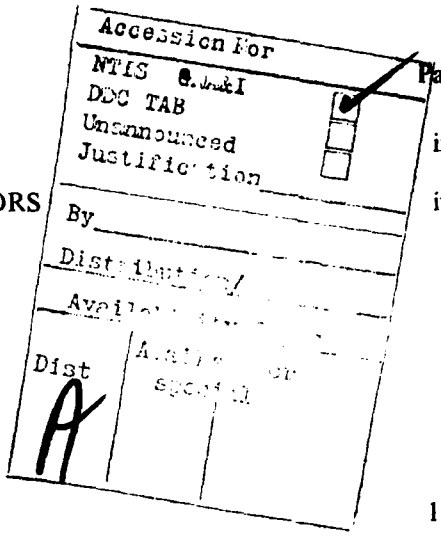


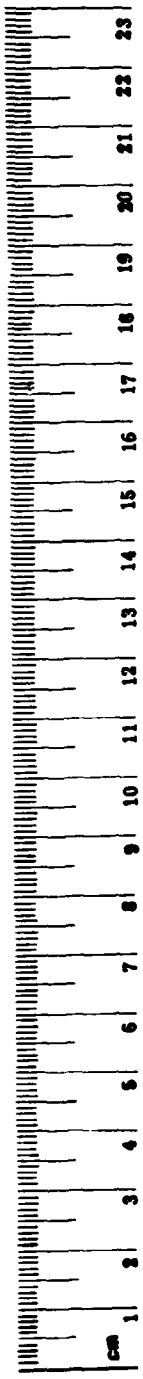
TABLES

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

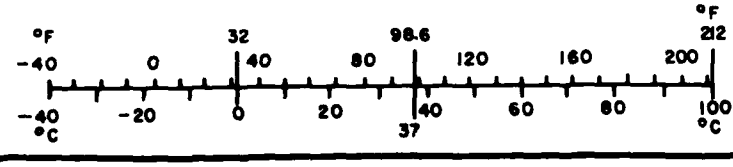
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric tons	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	C

* 1 in = 2.54 cm (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10 000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric tons (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



COMMERCIAL AUTOMOTIVE ENGINE OILS –

A LABORATORY ASSESSMENT OF THEIR QUALITY

I. INTRODUCTION

The Commercial Commodity Acquisition Program (CCAP), established recently within the Department of Defense (DOD), recommended possible use of products procured under commercial industry standards in lieu of those now being procured under government specifications, including Qualified Products Listings (QPL). The CCAP evolved from a General Accounting Office report, entitled "Government Specifications for Commercial Products – Necessary or a Wasted Effort," which recommended that both General Services Administration and DOD should consider changing procurement regulations to justify government specifications on the basis of cost versus projected benefits.

Military specifications for automotive engine oils have been and continue to be questioned in view of the availability of commercial engine oils within the civilian sector. The two major specifications used by the Department of the Army, DOD, and other Federal user agencies are: MIL-L-2104, "Lubricating Oil, Internal-Combustion Engine, Tactical Service," and MIL-L-46152, "Lubricating Oil, Internal Combustion Engine, Administrative Service." Automotive engine oils meeting these Military Specifications have been designed to provide satisfactory performance in two-cycle and four-cycle liquid and air-cooled internal combustion engines operating under a wide range of environmental and usage conditions. These satsifactory performance characteristics (i.e., detergency/dispersiveness, absence from sludge formation, oxidation properties, etc.) are attained by careful selection of lubricant basestock components and specific additive combinations which usually include an antioxidant, detergent/dispersant, pour-point depressant, viscosity index improver, antifoam agent, anti-wear additive, and rust preventative/corrosion inhibitors. This careful balance of additive components is finalized into a formulation only after extensive laboratory and engine dynamometer testing have insured the maximum response of additives to the particular lubricant basestock in meeting the performance levels defined by the particular specification. The recommended purchasing of commercially available products from a wide range of suppliers could result in acquiring products into the military supply system that do not adhere to the specification required for the automotive engine oils. This, in turn, could lead to serious engine problems if the required standards are not met fully. MERADCOM maintains the custodial responsibility within DOD for automotive (ground) engine lubricating oils; therefore, a program was initiated to generate technical data that critically identifies the relative quality of off-the-shelf commercial automotive oils. This report describes the results of a critical analysis of commercial off-the-shelf automotive engine oil.

II. DETAILS OF TEST

a. Sample Selection. Commercial automotive engine oils are not available through normal government procurement channels. The government procures automotive engine oils through a contract bid/solicitation process which leads to the development of 6-month contrac bulletins for specific regions within the US. The process of bid/solicitation for specific geographical regions leads to the awarding of contracts to low bidders. Since there is a direct relationship between quality level and cost, the government generally procures the lower level products which just meet the required performance levels.

To insure a meaningful and realistic assessment of commercial engine oil quality as it would apply to the proposed CCAP, MERADCOM adopted this same philosophy in procuring the commercial oils. The guidelines established were to procure off-the-shelf re-branded oils of at least American Petroleum Institute (API) SE performance level and falling into the Society of Automotive Engineers (SAE) 10W-30 viscosity range. A brief explanation of the API Performance Classification is provided in the Appendix. The rationale upon which these parameters were established follows:

- Re-branded automotive engine oils (i.e., not labeled by major oil companies) represent a bulk of the product which is procured through Defense Logistics Agency.

- SE performance level would be required if commercial substitutes for MIL-L-46152 were agreed to eventually.

- SAE 10W-30 viscosity grade was specified since these oils are considered to be not as high in quality levels as the SAE 10W-50, SAE 5W-40, etc., products. The SAE 10W-50, etc., are regarded to be premium-line engine oils.

Using this system of selection, commercial automotive engine oils were purchased from local discount stores, automotive supply houses, and food chain stores. Seventeen commercial automotive engine oils advertised to be at least API SE performance level were purchased; however, 3 were SAE 10W-40 products and 14 were SAE 10W-30. In addition, one MIL-L-46152 SAE 10W-30 qualified product was included to provide a baseline. This sampling of commercial products was modified later by the addition of three commercial engine oils having the SA/SB performance classification. These were included to represent the worst-case condition. In total, 21 were subsequently evaluated. Table 1 shows the products evaluated and the particular performance level identifications on the containers. It should be noted

Table 1. Commercial Engine Oil Samples Evaluated

Sample No.	Advertised Performance Level	Viscosity Grade
1	MIL-L-46152, MIL-L-2104B, GM-6136M, M2-C101-C, SE	SAE 10W-40
2	SE, SD, MS	SAE-10W-30
3	MIL-L-46152, SC, SE, CA, CB	SAE 10W-40
4	M2C101-B, GM6041-M, GM6042-M, MS, DM, SE	SAE 10W-30
5	SE, SD, CB, CC, MS, DG, DM	SAE 10W-30
6	SE, CB, CC	SAE 10W-30
7	SE, CC, MS	SAE 10W-30
8	MIL-L-46152, MIL-L-2104B, M2C101C, GM6136M, SE, SD, SC, SB, CC	SAE 10W-30
9	SE, SD, CB, CC, MS, DG, DM	SAE 10W-30
10	SB, SC, SD, SE, CA, CB	SAE 10W-30
11	MIL-L-46152, MIL-L-2104B, SE	SAE 10W-30
12	SA, SB, SC, SD, SE, CC	SAE 10W-40
13	SA, SB, SC, SD, SE, CC	SAE 10W-30
14	SE, CC	SAE 10W-30
15	MS	SAE 10W-30
16	Meets all car manufacturer's specs.	SAE 10W-30
17	SC, SD, SE, ML, MM, MS, DG	SAE 10W-30
18	Reference MIL-L-46152 Qualified Product	SAE 10W-30
19	SA, SB	SAE 30
20	SA, SB	SAE 30
21	SA, SB	SAE 30

that 1-gallon samples of each product were purchased. When individual quart containers were purchased (as was the case with a majority of the products), each quart sample was analyzed by infrared spectrophotometry to insure consistency and uniformity of product prior to admixing. The chemical/physical property data on the MIL-L-46152-approved product are shown in Table 2.

Table 2. Inspection Data on Qualified MIL-L-46152 Sample
(Product Identified as Sample No. 18)

Inspection Tests	Results	MIL-L-46152 Requirements*
Gravity, °API	29.2	Report
Flash Point	430	400 MIN
Viscosity @210°F cSt	11.62	9.6 to 12.9
Viscosity @100°F cSt	72.48	Report
Pour Point, °F	-50	-25 MAX
Carbon Residue (Ramsbottom), wt%	1.22	Report
Sulfated Ash, wt%	1.14	Report
Sulfur, wt%	0.427	Report
Zinc, wt%	0.180	Report
Phosphorous, wt%	0.160	Report
Calcium, wt%	0.276	Report
Foaming Tendencies, ml:		
Sequence I	0	25 ml MAX
Sequence II	110	150 ml MAX
Sequence III	10	25 ml MAX
Foam Stability, ml:		
Sequence I	0	0 ml MAX
Sequence II	0	0 ml MAX
Sequence III	0	0 ml MAX

* Requirements pertain to the grade 10W-30.

b. Laboratory Analyses. Ideally, the sole indicator of engine oil quality rests in the engine dynamometer sequence tests. Because of funding and manpower constraints as well as nonavailability of large sample batches, engine dynamometer sequence tests were not conducted. As an alternative, the standard inspection tests were conducted on all samples including additional laboratory performance-type tests. The testing scheme is given in Table 3. It should be noted that these tests were not used

Table 3. Test Series Performed on Commercial Oils

American Society for Testing Materials Test	Method Title
D92	Flash Point by Cleveland Open Cup
D97	Test for Pour Point
D130	Test for Copper Strip Corrosion (3 hours @ 212°F)
D287	Test for API Gravity (Hydrometer Method)
D445	Kinematic Viscosity @ 100°F and 210°F
D482	Test for Total Ash
D524	Ramsbottom Carbon Residue
D874	Sulfated Ash from Lubricating Oils and Additives
D892	Test for Foaming Characteristics
D1552	Sulfur in Petroleum Products (High-Temperature Method)
D1744	Water in Liquid Petroleum Products by Karl Fischer Reagent
D2266	Wear Preventive Characteristics (Four-Ball Method)
D2270	Calculated Viscosity Index from Kinematic Viscosity
Not assigned	Spectrographic Metal Analysis (Atom-Counter Method)

specifically to identify performance levels per se. They would provide a profile or fingerprint, however, as to types of additive treatments and levels. Further, the standard laboratory inspection tests would reveal whether any of these formulated products passed the standard requirements such as foam characteristics, pour point, etc. In general, the intent in using the testing scheme is as follows:

- D482 (total ash) and D874 (sulfated ash) – Generally additive-treated motor oils have appreciable ash contents signifying the presence of metal, phosphorous, or sulfur compounds (i.e., ash values in the range of 1.0% is considered typical for MIL-L-46152 products).

- D287 (API gravity, hydrometer method) – Generally used to indicate product uniformity and type.

- D1744 (water in liquid petroleum products by Karl Fischer Reagent) – Used to determine if contamination with water has occurred.

- D524 (Ramsbottom carbon residue) – Gives an estimate of the amount of additives and a measure of oil volatility.

- D97 (pour point) – Provides indication of the type of crude, degree of dewaxing, and presence of pour point depressants.

- D445 (kinematic viscosity @ 100°F and 210°F) – Useful for determining grades of oil.

- D92 (flash point by Cleveland Open Cup) – Gives rough index of oil volatility and type but not of quality.

- D130 (copper strip corrosion, 3 hours @ 212°F) – Slightly tarnished or untarnished strips indicate absence of elemental sulfur or sulfur compounds that are likely to be corrosive in service.

- D2270 (calculated viscosity index) – Low values would indicate poor resistance to viscosity change with temperature, and high values indicate maximum resistance. Low viscosity index may mean insufficient viscosity improver.

- D1552 (sulfur in petroleum products) – A high sulfur content in formulated oils is desirable as this is indication of sufficient additive treatment.

- D2266 (wear-preventive characteristics, four-ball method) – A measure of the lubricity of oil and sufficient anti-wear protection. Defines type and quantity of additives in oils.

- D892 (foaming characteristics) – Measures the tendency of oils to foam excessively under service conditions.

- No number (spectrographic analysis) – Generally indicates level and type of additive package/treatment.

III. RESULTS OF TEST

The results of the tests conducted on the 21 oil samples are presented in Tables 4, 5, 6, and 7. Analyses which did not fall within the current specification limits of MIL-L-46152 are noted by square designation on those values. Many of these commercial oils appear not to comply with even the physical/chemical requirements of MIL-L-46152. The test limitation wherein most of the oils failed was Foam Characteristics. Other failures were Flash Point, Kinematic Viscosity, and Pour Point. One sample gave a Viscosity Index (VCI) of 52, which indicated either absence of sufficient VI improver or use of basestock components having low VI quality.

Apart from the obvious failures in meeting the above mentioned tests, many of these formulated oils appeared to have low additive treatment levels. This was evident in the low or non-existent Ash/Sulfated Ash values and metal analyses. Six formulated products had Ash/Sulfated Ash values that were considered to be completely inadequate when compared with the Ash/Sulfated Ash levels of products qualified under MIL-L-46152. These low levels of Ash/Sulfated Ash of the six suspect products compared favorably to the values found for the three so-called "Non-Detergent" SA-SB oil samples (Nos. 19, 20, and 21). To confirm the probable absence of sufficient additive treatment further, the Nitrogen content was determined on the suspect samples. Where ashless detergent additives are used, Nitrogen will be present. As noted in Table 7, the amount of Nitrogen present was not commensurate with an oil formulated to meet SE performance levels.

To identify more clearly the suspected inadequate additive treatment of the six formulated products (Samples 4, 7, 11, 15, 16, and 17), Table 8 was prepared to compare these "marginal treat" products with the three SA-SB products and the reference MIL-L-46152 oil. When the tabulated data are reviewed, especially against the reference MIL-L-46152 product (Sample 18), the differing levels in additive treatment are most obvious. Based upon these data, the six oils advertised to be at least "SE Performance level" are, in reality, equivalent to the SA-SB Performance Level.

Table 4. Inspection Tests Data on Oil Samples

Sample No.	Total Ash, wt%	API Gravity @60°F	Water, wt%	Carbon Residue, wt%	Pour Pt, °F	Sulfated Ash, wt%
1	1.28	28.4	0.2568	0.87	-25	1.40
2	0.45	30.1	0.1277	0.64	-25	0.53
3	0.70	29.1	0.1980	0.69	-25	0.74
4	0.04	32.0	0.0148	0.11	-25	0.05
5	0.71	22.5	0.2104	0.99	-40	0.73
6	0.45	30.1	0.0725	0.62	-35	0.55
7	0.23	29.5	0.0276	0.33	-30	0.28
8	0.66	30.0	0.1619	0.61	-25	0.72
9	0.71	29.9	0.1419	0.89	-25	0.75
10	0.70	30.1	0.2570	0.94	-25	0.73
11	0.00	24.5	0.0884	0.10	[-20] *	0.00
12	0.48	29.9	0.1261	0.56	-50	0.56
13	0.52	29.8	0.1443	0.66	-35	0.61
14	0.60	30.6	0.1879	0.73	-30	0.64
15	0.00	24.5	0.0192	0.12	-30	0.00
16	0.11	31.8	0.0334	0.20	-30	0.13
17	0.00	29.4	0.0194	0.12	-35	0.00
18	0.96	29.1	0.110	0.93	-35	1.14
19	0.00	ND**	ND	0.10	ND	0.00
20	0.29	ND	ND	0.50	ND	0.36
21	0.12	ND	ND	0.29	ND	0.13
(Spec Limits) MIL-L-46152 Limits					-25°F, MAX	

* Square indicates not within current specification limits.

** ND – Not Determined.

Table 5. Inspection Test Data on Oil Samples

Sample No.	Kin Vis @ 100°F, cSt	Kin Vis @ 210°F, cSt	Flash Point °F	Copper Corrosion	Viscosity Index	Sulfur wt%
1	95.32	13.64	430	1A	155	0.45
2	72.53	10.27	440	1A	137	0.43
3	98.53	13.78	405	1A	152	0.50
4	73.39	10.57	430	2A	141	0.23
5	67.05	10.52	340 *	1A	157	0.47
6	66.29	11.17	445	1A	173	0.35
7	73.65	11.18	420	1A	154	0.44
8	76.91	10.84	430	1A	139	0.73
9	73.78	10.53	420	1A	140	0.45
10	67.94	10.35	410	1A	150	0.25
11	58.03	10.85	325	1A	193	1.57
12	76.11	12.98	435	1A	184	0.59
13	65.08	11.05	440	1A	174	0.46
14	73.76	10.78	410	1A	145	0.34
15	51.70	6.03	390	1A	52	0.09
16	75.30	10.88	415	2B	144	0.17
17	82.63	10.92	415	1A	129	0.18
18	72.92	11.36	415	1A	160	0.55
19	ND**	ND	495	ND	ND	0.18
20	ND	ND	420	ND	ND	0.36
21	ND	ND	305	ND	ND	0.13
(Spec Limits) MIL-L-46152 Limits		9.6 MIN <12.9 MAX	400°F, MIN			

* Not within current specification limits.

** ND – Not Determined.

Table 6. Inspection Test Data on Oil Samples Foam-Tendencies (ml)

Sample No.	Sequence I, ml	Sequence II, ml	Sequence III, ml	Four-Ball Wear Test Scar Diameter, mm
1	105 *	70	120	0.0259
2	5	75	5	0.0223
3	0	65	0	0.0275
4	260	25	240	0.0341
5	15	70	0	0.0289
6	20	55	5	0.0255
7	10	20	30	0.0236
8	15	20	0	0.0282
9	10	20	25	0.0256
10	25	90	15	0.0245
11	300	70	280	0.0710
12	230	140	270	0.0264
13	240	60	225	0.0254
14	25	50	25	0.0232
15	20	20	70	0.0918
16	5	40	0	0.0774
17	105	50	140	0.0985
18	5	10	0	0.0284
19	ND**	ND	ND	0.0440
20	ND	ND	ND	0.0249
21	ND	ND	ND	0.0647
(Spec Limits)				
MIL-L-46152	25, MAX	150, MAX	25, MAX	

* Not within current specification limits.

** ND - Not Determined.

Table 7. Inspection Test Data on Oil Samples Metal-Analysis (p/m)

Sample No.	Sodium	Barium	Zinc	Calcium	Phosphorus wt%	Nitrogen wt%
1	20	10	1700	4300	0.15	.0025
2	15	5	820	900	0.07	ND*
3	15	5	1250	360	0.10	ND
4	5	135	60	130	0.01	ND
5	5	5	1000	43	0.12	ND
6	15	5	990	840	0.07	ND
7	10	5	350	560	0.03	ND
8	10	80	1500	180	0.12	ND
9	10	80	1500	225	0.14	ND
10	25	1	1350	70	0.13	ND
11	10	1	5	35	0.01	0.015
12	15	10	800	890	0.06	ND
13	15	5	1050	860	0.08	ND
14	15	5	1100	960	0.10	ND
15	5	0	17	55	0.01	0.018
16	5	275	110	235	0.02	ND
17	1	1	0	0	0.00	0.022
18	0	0	1800	2760	0.15	ND
19	8	10	18	18	0.01	ND
20	37	11	164	726	0.12	ND
21	10	10	147	36	0.09	ND

* ND Not Determined.

Table 8. Comparison of Marginal SE Oils with SA-SB Oils

Sample No.	Total Ash, wt%	Sulfated Ash, wt%	Carbon Residue, wt%	Sulfur, wt%	Phosphorus, wt%	Metals, p/m			Nitrogen, wt%
						Barium	Calcium	Zinc	
4	0.04	0.05	0.11	0.23	0.01	135	130	60	ND*
7	0.23	0.28	0.33	0.44	0.03	5	560	350	ND
11	0.00	0.00	0.10	1.57	0.01	1	35	5	0.015
15	0.00	0.00	0.12	0.09	0.01	0	55	17	0.018
16	0.11	0.13	0.20	0.17	0.02	275	110	235	ND
17	0.00	0.00	0.12	0.18	0.00	1	0	0	0.022
18	0.96	1.14	0.93	0.55	0.15	0	2760	1800	ND
Reference									
19	0.00	0.00	0.10	0.18	0.01	10	18	10	ND
20	0.29	0.36	0.50	0.36	0.12	11	726	164	ND
21	0.12	0.13	0.29	0.13	0.09	10	36	147	ND

* ND – Not Determined.

The absence of phosphorus and zinc would indicate the resultant engine oil to have relatively poor anti-wear protection and resistance to oxidation. It should be understood that an engine oil specification like MIL-L-46152 is a "performance-type" and not "composition-type" specification. However, to meet the performance requirements of an "SE" quality level formulation, certain ingredients must be present inherently. For this reason, the above comments regarding inadequate additive treatment are pertinent.

As was mentioned previously, the evaluation of the commercial oils was limited to laboratory physical/chemical inspection-type testing. Ideally, performance evaluation clearly would have identified those products which were treated inadequately to meet their advertised can designations. However, one test was performed which relates to one aspect of performance characteristics; namely, wear protection (D2266). These data are presented in Table 6 under the column heading, "Four-Ball Wear Test." The lower the scar diameter, the more anti-wear protection is indicated. A review of these data against the relative level of additive treatment (as predicted by Ash/Sulfated Ash and Metals) revealed that the six oil products (Samples 4, 7, 11, 15, 16, and 17) had high scar diameters indicating poor anti-wear protection; Sample No. 4 was slightly higher than the average scar diameter for the other 12 commercial oils (0.0255 mm). However, one of the SA-SB non-detergent oil samples (Sample 20) also had a low scar diameter which introduced a major variable into this approach. For this reason, comprehensive engine testing is required to assess fully the anti-wear performance of fully formulated oils for internal combustion engines.

IV. CONCLUSIONS

In an attempt to screen the quality of commercial off-the-shelf automotive engine oils, 17 products were purchased locally and subjected to the specification requirements given in MIL-L-46152. This laboratory assessment did not involve any engine performance testing but was to indicate whether any potential problems could occur if procurement of commercial automotive engine oils was mandated. Table 9 presents a summary of those products evaluated against limiting requirements in Specification MIL-L-46152. Of the 17 products, 11 failed to meet one or more of the specification's physical/chemical requirements. Additionally, 6 of the products appeared to be formulated with insufficient additives as evidenced by extremely low values for Ash/Sulfated Ash, Carbon Residue, and Metals content. These 6 oils were Samples 4, 7, 11, 15, 16, and 17; all had an overall "Failure" rating except Sample 16 which passed all the physical/chemical specification requirements.

Of major concern is the fact that all of these products were advertised to meet the API SE Performance level. The use of a non-formulated or SA-SB oil in commercial-design automotive engines can create severe problems and increase maintenance costs significantly for post-camp-station motor pool operations.

Table 9. Summary of Commercial Products Meeting MIL-L-46152 Physical/Chemical Specification Requirements

Sample No.	Kin Vis @ 210°F	Pour Point	Flash Point	Foam Tendencies			Overall Rating*
				Seq I	Seq II	Seq III	
1	P	P	P	F	P	F	F
2	P	P	P	P	P	P	P
3	P	P	F	P	P	P	F
4	P	P	P	F	P	F	F
5	P	F	F	P	P	P	F
6	F	F	P	P	P	P	F
7	F	F	P	P	P	F	F
8	P	P	P	P	P	P	P
9	P	P	P	P	P	P	P
10	P	P	P	P	P	P	P
11	P	F	F	F	P	F	F
12	P	P	P	F	P	F	F
13	F	P	P	F	P	F	F
14	P	P	P	P	P	P	P
15	F	P	F	P	P	F	F
16	P	P	P	P	P	P	P
17	F	P	P	F	P	F	F
18	P	P	P	P	P	P	P

Reference

* P indicates a Pass Rating; whereas, F indicates a Failure to meet the limiting specification requirement.

APPENDIX

COMMERCIAL ENGINE OIL PERFORMANCE CLASSIFICATIONS

In 1947, the American Petroleum Institute (API) adopted the first classification which included three types of oils (regular, premium, or heavy duty). This system was replaced in 1952 by classifications by engine type; i.e., ML, MM, and MS for gasoline engine oils and DF, DM, and DS for diesel engine oils. The "M" and "D" in classifications were revised in 1955 and again in 1960 which remained in effect until the current system was introduced in 1971. Under the current system, oils are designated SA, SB, SC, SD, SE, CA, CB, CC, and CD and apply to passenger cars, gasoline- and diesel-powered trucks, and gaoline- and diesel-powered off-highway equipment.

Description of commercial performance classifications:

Letter Designation	API Engine Service Description	ASTM Engine Oil Description
SA	Utility Gasoline and Diesel Engine Service: Service typical of engines operated under such mild conditions that the protection afforded by compounded oils is not required. This classification has no performance requirements.	Oil without additive except that it may contain pour and/or foam depressants.
SB	Minimum Duty Gasoline Engine Service: Service typical of engines operated under such mild conditions that only minimum protection afforded by compounding is desired. Oils designed for this service has been used since the 1930s and provide only anti-scuff capability and resistance to oil oxidation and bearing corrosion.	Provides some anti-oxidant and anti-scuff capabilities.

Description of commercial performance classifications (Continued)

Letter Designation	API Engine Service Description	ASTM Engine Oil Description
SC	1964 Gasoline Engine Warranty Service: Service typical of gasoline engines in 1964-1967 models of passenger cars and trucks operating under engine manufacturers' warranties in effect during those model years. Oils designed for this service provide control of high and low temperature deposits, wear, rust, and corrosion in gasoline engines.	Oil meeting the 1964-1967 requirements of the automobile manufacturers. Intended primarily for use in passenger cars. Provides low temperature anti-sludge and anti-rust performance.
SD	1965 Gasoline Engine Warranty Maintenance Service: Service typical of gasoline engines in 1968–1970 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Also may apply to certain 1971 and later models, as specified (or recommended) in the owner's manuals. Oils designed for this service provide more protection against high and low temperature engine deposits, wear rust, and corrosion in gasoline engines than oils which are satisfactory for API Engine Service Classification SC and	Oil meeting the 1968-1971 requirements of the automobile manufactures. Intended primarily for use in passenger cars. Provides low temeperature anti-sludge and anti-rust performance.

Description of commercial performance classifications (Continued)

Letter Designation	API Engine Service Description	ASTM Engine Oil Description
	and may be used when API Engine Service Classification SC is recommended.	
SE	1972 Gasoline Engine Warranty Maintenance Service: Service typical of gasoline engines in passenger cars and some trucks beginning with 1972 and certain 1971 models operating under engine manufacturers' warranties. Oils designed for this service provide more protection against oil oxidation, high temperature engine deposits, rust, and corrosion in gasoline engines than oils which are satisfactory for API Gasoline Engine Warranty Maintenance Classifications SD or SC and may be used when either of these classifications is recommended.	Oil meeting the 1972 requirements of the automobile manufacturers. Intended primarily for use in passenger cars. Provides high temperature anti-oxidation, low temperature anti-sludge and anti-rust performance.
CA for Diesel Engine Service	Light Duty Diesel Engine Service: Service typical of diesel engines operated in mild to moderate duty with high quality fuels. Occasionally has included gasoline engines in mild service. Oils designed for this service were used widely in the 1940s and 1950s. These oils provide protection from bearing corrosion and from high temperature deposits in	Oil meeting the requirements of MIL-L-2104A. For use in gasoline and naturally operated diesel engines operated on low sulfur fuel. The MIL-L-2104A specification was issued in 1954.

Description of commercial performance classifications (Continued)

Letter Designation	API Engine Service Description	ASTM Engine Oil Description
	normally aspirated diesel engines when using fuels of such quality that they impose no unusual requirements for wear and deposit protection.	
CB for Diesel Engine Service	Moderate Duty Diesel Engine Service: Service typical of diesel engines operated in mild to moderate duty, but with quality fuels which necessitate more protection from wear and deposits. Occasionally has included gasoline engines in mild service. Oils designed for this service were introduced in 1949. Such oils provide necessary protection from bearing corrosion and from high temperature deposits in normally aspirated diesel engines with higher sulfur fuels.	Oil for use in gasoline and naturally aspirated diesel engines. Includes MIL-L-2104A oils where the diesel engine test was run using high sulfur fuel.
CC for Diesel Engine Service	Moderate Duty Diesel and Gasoline Engine Service: Service typical of lightly supercharged diesel engines operated in moderate to severe duty and has included certain heavy-duty, gasoline engines. Oils designed for this service were introduced in 1961 and used in many trucks and in industrial and construction equipment and farm tractors. These oils	Oil meeting requirements of MIL-L-2104B. Provides low temperature anti-sludge, anti-rust, and lightly supercharged diesel engine performance. The MIL-L-2104B specification was issued in 1964.

Description of commercial performance classifications (Continued)

Letter Designation	API Engine Service Description	ASTM Engine Oil Description
	provide protection from high temperature deposits in lightly supercharged diesels and also from rust corrosion, and low temperature deposits in gasoline engines.	
CD for Diesel Engine Service	Severe Duty Diesel Engine Service: Service typical of supercharged diesel engines in high-speed, high-output duty requiring highly effective control of wear and deposits. Oils designed for this service were introduced in 1955 and provide protection from bearing corrosion and from high temperature deposits in supercharged diesel engines when using fuels of a wide range of quality.	Oil meeting Caterpillar Tractor Co. certification requirements for Superior Lubricants (Series 3) for Caterpillar diesel engines. Provides moderately supercharged diesel engine performance. The certification of Series 3 oil was established by Caterpillar Tractor Co. in 1955. The related MIL-L-45199 specification was issued in 1958.

Current API Engine Service Classifications	Previous API Engine Service Classification
Service Station Engine Service	
SA	ML
SB	MM
SC	MS (1964)
SD	MS (1968)
SE	None
Commercial and Fleet Engine Services	
CA	DG
CB	DM
CC	DM
CD	DS

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